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Differences in Neurocognitive Abilities in Premature and Full-term Infants at 5 Months of Age

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Abstract

It is known that prematurity is a risk for neurodevelopmental disorders. Most of the studies were dedicated to those children who have reached the preschool and primary school age. However, the impact of prematurity on neurocognitive functions in the early stages of development is not investigated thoroughly. The aim of this research was to reveal the differences in neurocognitive development in premature (24 babies) and gender-matched healthy mature full-term infants (31 participants) at 5 months of age. The gestational age of preterm children was between 29 and 35 weeks. The Bayley Scales of Infant and Toddler Development (3rd Edition) were used to evaluate the neurocognitive abilities in children. The one-way ANOVA has revealed that premature infants at 5 months of corrected age performed significantly ($p \leq 0.05$) more poorly than the full-term infants on cognitive scale, receptive language, gross and fine motor. No significant differences ($p \leq .05$) were found between preterm and full-term children on expressive language. In view of the obtained results, it can be assumed that the prematurity has specific (not global) negative effect on neurocognitive development at 5 months of age.

Keywords: premature infants, neurocognitive development, Bayley Scales of Infant and Toddler Development (3rd Edition)

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1. Introduction

At present, children born between the 22nd to 37th weeks of fetal development (e.g., less than 259 days) and have a body weight between 500 and 2500 g are considered premature [1]. The frequency of preterm births ranges from 6% to 14.5% and is steadily increasing especially in developed countries. There are approximately 15,000,000 children born premature each year worldwide. In recent years, the level of survival of low preterm infants has increased from 50 to 85% [2, 3].

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Previous researches have shown that prematurity is a risk factor delaying the development of neurocognitive functions and the brain of children appearing during the first years of life [4–6]. These children were found to have deficits in executive functions, a delay in the development of impressive and expressive communication, and a lack of motor skills compared to the typically developing ones [7–9]. In the later stages of ontogeny, premature infants continue to show problems in the development of neurocognitive functions, which significantly increases the likelihood of cognitive, language and motor disorders, learning disability at school [10, 11]. These changes of ontogeny suggest the importance of early assessment of neuropsychological development found in preterm infants with the aim of monitoring and developing measures for early intervention.

However, the impact of prematurity on neurocognitive functions in the early stages of ontogenesis has not been studied enough. Previous research has focused mainly on those children who reached preschool or primary school age, and little attention has been paid to the evaluation of neurocognitive development in the early stages of life (e.g., under one year of age) [3, 7, 10–13].

To assess the neurocognitive development of infants a variety of diagnostic tools and approaches are used (e.g., Denver developmental screening test (DDST), Alpern-Boll Developmental Profile, Kent Infant Development Scale (KIDS), The Neonatal Behavioural Assessment Scale (NBAS), etc.), leading to difficulties in the comparison of the results obtained by different studies. Currently the most commonly used technique is Bayley Scales of Infant and Toddler Development, created at the University of California Berkeley, and has been used in a very large number of studies. Examination procedures are characterized by a high degree of formality through diagnostic requirements by following instructions thoroughly. Bayley Scale is recognized as the 'gold standard' for assessing the early development of the child trending toward widespread use in preterm infants, observed in the United States and worldwide [12, 14–23].

Currently researchers use the 3rd edition of Bayley Scales, which includes 5 scales and allows assessing cognitive, speech and motor development, along with social and emotional skills and adaptive behavior from children aged 16 days to 42 months. It is important to note that the latest edition of the Bayley scales includes both direct tests (conducted directly by the clinician or researcher) and indirectly through a questionnaire completed by the parent or guardian of the child.

To date, there have been relatively few studies of premature infants using the 3rd edition of Bayley scales [25–27]. In Russia, there is no publication of research results conducted based on this version of the methodology. In this way, it becomes critical to obtain data on the Russian population of children using the Bayley Scales of Infant and Toddler Development (3rd Edition), and also to conduct research on the neurocognitive development of preterm infants during the first year of life. The ability to track the neurocognitive profile, the rate of backwardness and variants of disharmonious development make it possible to identify the most critical periods in the development of premature children, which can serve as a basis for developing and implementing effective methods of early intervention [28].

The aim of research was to reveal the differences in neurocognitive development in premature and mature full-term infants at 5 months of age.

2. Methodology

This research was a part of longitudinal study designed to track the developmental trajectory in cognitive measures of preterm infants. Experimental group consisted of 24 premature children at 5 months corrected age (5.28 ± 0.49 months of age). We used the following including criteria for premature participants: born at 29–35 weeks' gestation, birth weight more than 1,0 kg; absence of severe malformations of brain, heart and other internal organs; absence of hemorrhage and hypoxic injury of any localization and rate in brain by the results of neurosonography; absence of hyperbilirubinemia or any intrauterine infection. The control group consisted of 31 gender matched healthy full-term children (5.46 ± 0.34 months of age) at 5 months of age.

The Bayley Scales of Infant and Toddler Development (3rd Edition, BSID-III) were used to evaluate the neurocognitive abilities in infants.

BSID-III includes 5 scales and allows assessing cognitive, speech and motor development, along with social and emotional skills and adaptive behavior from children aged 16 days to 42 months.

Cognitive scales are aimed at studying the sensorimotor development of the child, their strategy of understanding new objects, manipulation of objects, spatial representation, and the dispersal of attention. The speech scale consists of two parts, the receptive and expressive communication scales. The receptive communication scale shows how well a child recognizes sounds, understands spoken words and instructions, and identifies objects and images. Infants evaluate the response to various sounds in the environment such as the sound of a rattle, a bell, the rustling of paper, or a human voice). The scale of expressive communication makes it possible to reveal how well a child perceives sounds, gestures, or words through interaction, what forms of

Table 1: Group performance on 5 scales from BSID-III for control and experimental groups.

	Cognitive Scale	Receptive language	Expressive language	Fine motor	Gross motor
Full-term infants, $n = 31$	27.23 ± 2.85	9.03 ± 1.25	7.58 ± 1.57	18.26 ± 2.54	21.68 ± 2.57
Premature infants, $n = 24$	24.33 ± 3.31	8.04 ± 1.00	8.08 ± 2.10	15.88 ± 3.19	18.17 ± 3.41

verbal communication they use (e.g., a smile, different sounds, the process of walking or laughing). The motor scale also has two parts, the scales of fine or gross motor development. The scale of fine motor development allows the study of capturing objects and the ability to manipulate them, assess perceptual motor integration, and motor planning. Researchers assess the tracking skill by observing infant's eyes fixated on an object and the way they coordinate their actions to reach for the object, manipulate and compare them. The scale of a gross motor development describes what positions the child can take during motor activity, the purposefulness of movements and coordination besides the ability to maintain equilibrium. The Adaptive Behavior Scale assesses the ability of child to adapt to different requirements and conditions of daily life. The scale of social and emotional skills reveals the compliance of child with the basic norms of social and emotional development in different age periods.

3. Results

The mean and standard deviation in Raw Scores was calculated for each scale from BSID-III in control and experimental groups. Table 1 shows the means and standard deviations for Raw Scores in 5 scales.

To reveal group differences in level of performance for each scale from BSID-III we conducted the one-way ANOVA. A summary of the one-way ANOVA results is provided in Table 2.

As can be seen in Table 2, the one-way ANOVA revealed that premature infants performed significantly ($p \leq 0.05$) more poorly than the full-term children according to data obtained during the assessment on cognitive scale, receptive language, gross and fine motor scales. No significant differences ($p \leq 0.05$) were found between preterm and full-term infants on expressive language scale.

Table 2: Analysis of variance.

	F	*p*
Cognitive Scale	**12.12**	0.001
Receptive language	**10.06**	0.002
Expressive language	1.03	0.314
Fine motor	**9.50**	0.003
Gross motor	**18.96**	0.000
Note: Significant F values are in bold type.		

4. Discussion

The received results correspond to data obtained by other researchers [4–9]. Particularly, it was shown that there is a delay in the development of sensory, motor, verbal and cognitive functions in premature children, and it was suggested that the factor of prematurity should negatively affect all aspects of neurocognitive development in children. However, our results suggest that prematurity in the early stages of development has a selective negative effect on the development of neurocognitive functions in children. In particular, in preterm infants at 5 months of age there is a delay in the development of cognitive abilities, receptive language, fine and gross motor functions. At the same time, the rates of development of expressive language in premature infants do not significantly differ from full-term children.

Why did not the premature participants have delay in expressive language at 5 months of age? We have two hypotheses for explanation of this result. On the one hand, it can be explained by the fact that the active maturation of brain mechanisms responsible for expressive language occurs at later stages of development in children, when the prematurity may begin to have a negative impact on this function. We are going to check this assumption at the next stages of this longitudinal study, when children from our experimental and control group will reach 10 and 14 months of age.

Also there is another possible explanation. It can be assumed that preterm babies may have advantages in some functions in comparison to the full-term infants. This assumption can be explained by the fact that premature birth can be a stimulating factor for the maturation of some brain mechanisms in premature children. For example, it was shown that preterm infants were faster in disengaging and shifting their attention and gaze from a stimulus in their central visual field to the periphery in comparison to the full-term children [29]. It is possible that early visual, auditory and tactile sensory stimulation in premature newborns can promote accelerated processes of maturation of some brain mechanisms in infants.

According to limitations of this research (small sample, one age group, cross-sectional design, one experimental paradigm for assessment of neurocognitive functions), we need to obtain additional data to answer questions that appeared in this study.

5. Conclusions

This study has revealed that premature infants at 5 months of corrected age have a delay in the development of cognitive abilities, receptive language, gross and fine motor in comparison to the full-term children. However, no significant differences were found between preterm and full-term participants on expressive language. In view of the obtained results it can be assumed that the prematurity has specific (not global) negative effect on neurocognitive development of children at 5 months of age.

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